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APPLICATION

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TITLE: TUNABLE DISPERSION COMPENSATION USING A PHOTOELASTIC MEDIUM

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TUNABLE DISPERSION COMPENSATION USING A PHOTOELASTIC MEDIUM

Background

This invention relates generally to compensating for dispersion in optical systems.

Optical systems, such as wavelength division multiplexed (WDM) optical communication networks, are subject to dispersion. Dispersion is due to the dependence of the velocity of light on the wavelength of light, as a light signal propagates through an optical medium. Dispersion ultimately results in pulse spreading, limiting the bandwidth of a common optical transport medium.

Currently, dispersion compensating fiber spools or fiber Bragg gratings are used to provide a fixed amount of dispersion with the required positive or negative sign. In other words, if the induced dispersion is positive, the dispersion compensating fiber may introduce a compensating negative dispersion.

However, the extent of dispersion that may be induced at any given instance, may be variable through the optical medium. It may vary as a function of temperature, wavelength, change in the communication link length, and other criteria. As a result, a fixed dispersion compensator is of relatively limited usefulness.

Thus, there is a need for better ways to provide dispersion compensation in optical systems.

Brief Description of the Drawings

Figure 1 is a schematic depiction of one embodiment of the present invention; and

Figure 2 shows the calculated dispersion induced by a photoelastic medium as a function of applied stress in accordance with one embodiment of the present invention.

Detailed Description

Referring to Figure 1, an optical medium 10 may be a fiber, a planar waveguide, or a planar light wave circuit, or a free-space material to mention a few examples. A light signal 16 is provided to the optical medium 10 and an output signal 18 exits from the optical medium 10. The optical medium 10 itself or components which pass either the input signal 16 or the output signal 18 may induce dispersion.

The induced dispersion may be compensated for by a tunable dispersion compensator utilizing the photoelastic property of the optical medium 10. In one embodiment, the tunable dispersion compensator may include a material 12 that expands or contracts piezoelectrically in response to an induced voltage 14. In other words, in response to a change in voltage, the material 12 either expands, as

indicated by the arrows, or contracts in the opposite direction.

In one embodiment, the optical medium 10 is fixed to the material 12 so that when the material 12 expands, the optical medium 10 expands and vice versa. As a result, the piezoelectric material 12 can induce the stress within the optical medium 10.

In one embodiment, the optical medium 10 includes at least a portion which is photoelastic. Photoelasticity is the property of a material that its index of refraction changes with applied stress. As the light wave signal 16 propagates through the optical medium 10, an appropriately applied stress is applied through the piezoelectric material 12 either in a bulk-optic or guided-wave configuration.

The refractive index of the optical medium 10 can be changed by subjecting it to a force as indicated by the following equation:

$$n(\sigma) = n_0 - \frac{1}{2} n_0^3 q \sigma$$

where n_0 is the refractive index in the absence of a force, q is the elasto-optic constant of the material, and σ is the stress induced in the material due to the applied force. Thus, the stress-induced change in the refractive

index is a non-linear function of the stress-free index, which can be utilized to achieve tunable dispersion.

The corrective dispersion induced on the light signal 16 upon propagation through the optical medium 10 can be derived as:

$$D = -\frac{\lambda L}{c}\frac{d^2 n}{d\lambda^2} = \left[\left\{3n_0\left(\frac{dn_0}{d\lambda}\right)^2 + \frac{3}{2}n_0^2\frac{d^2 n_0}{d\lambda^2}\right\}q\sigma - \frac{d^2 n_0}{d\lambda^2}\right]\frac{\lambda L}{c}$$

where λ is the optical wavelength, L is the propagation length in the medium 10, and c is the light speed in vacuum. The corrective dispersion may be of the same magnitude, but opposite of the polarity of the induced dispersion so as to substantially cancel the induced dispersion.

Thus, referring to Figure 2, the applied corrective dispersion can be tuned as a function of the stress applied to the medium 10. The applied stress is shown on the horizontal axis, while the induced dispersion is shown on the horizontal axis. In this case, q is $-5\text{x}10^{-8}$ m^2/N, L = 10 cm. Thus, the possible dispersion correction in this example may extend from +300 ps/nm to -300 ps/nm. In other embodiments other materials having a different value of the elasto-optic constant (q) and length (L) may be used.

A suitable photoelastic medium may be bonded to the piezoelectric stage so that the required stress can be

imparted by an applied voltage. Alternatively, stress can be applied by subjecting the medium to a mechanical force. A device can also be made in a planar integrated format. For example, a silica-on-silicon platform may be used wherein the suitable photoelastic material is deposited in a waveguide form and the stress is applied either piezoelectrically or mechanically.

The dispersion achieved is modulated by simply varying the applied stress to the photoelastic medium. Thus, a less bulky tunable dispersion compensation device may be achieved and, in some embodiments, may be integrated with other optical components within the same package.

While the present invention has been described with respect to a limited number of embodiments, those skilled in the art will appreciate numerous modifications and variations therefrom. It is intended that the appended claims cover all such modifications and variations as fall within the true spirit and scope of this present invention.

What is claimed is: